MULTIMEDIA   UNIVERSITY

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FINAL EXAMINATION

TRIMESTER 2, 2019/2020

PPH0135 – ELECTRICITY AND MAGNETISM
(Foundation in Engineering)

29 FEBRUARY 2020
9.00 a.m – 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 7 pages excluding the cover page with 5 questions and appendices.

2. Attempt **ALL** questions. Distribution of the marks for each question is given.

3. Please write all your answers in the answer booklet provided.

QUESTION 1 [10 MARKS]

(a) In Figure Q1(a) below, the net electrostatic force acting on point charge B is zero.
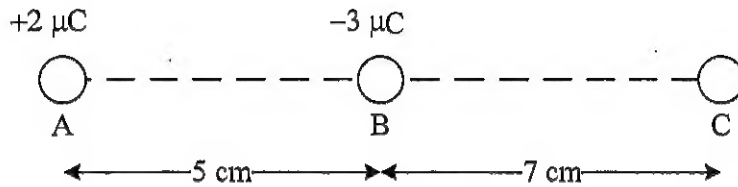
+2 μC   −3 μC

$\bigcirc$ — — — — — $\bigcirc$ — — — — — $\bigcirc$

A   B   C

←——5 cm——→←——7 cm——→

Figure Q1(a)

(i) What is the sign of point charge C? Explain your answer.   [1 mark]

(ii) Find the magnitude of point charge C.   [3 marks]

(iii) If the distance between point charges B and C is reduced to 5 cm, in which direction will point charge B accelerate? Explain your answer.
   [1 mark]

(b) Figure Q1(b) shows a combination of capacitors in a circuit. Each capacitor has a capacitance of 4.0 μF.

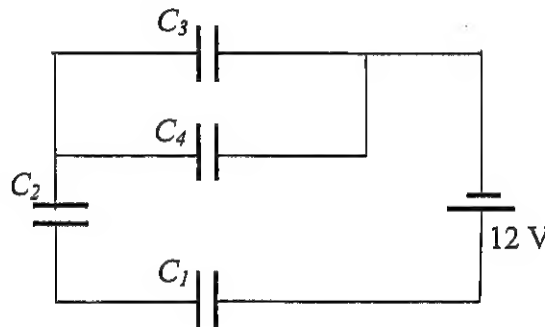Figure Q1(b)

(i) Determine the equivalent capacitance of the circuit.   [1½ marks]

(ii) Calculate the amount of charge stored in C_2.   [1 mark]

(iii) Determine the voltage across C_3.   [1½ marks]

(c) What are the two factors that can increase the capacitance value of a parallel-plate capacitor?
   [1 mark]

Continued...

QUESTION 2 [10 MARKS]

(a) Calculate the diameter of a 2.0 cm length of tungsten filament in a small light bulb if its resistance is 0.05 Ω.

[Given: resistivity of tungsten is 5.6×10^{-8} Ω.m]

[2 marks]

(b) By using Kirchhoff's rule, find each of the currents I_1, I_2, and I_3 for the circuit in Figure Q2(b).
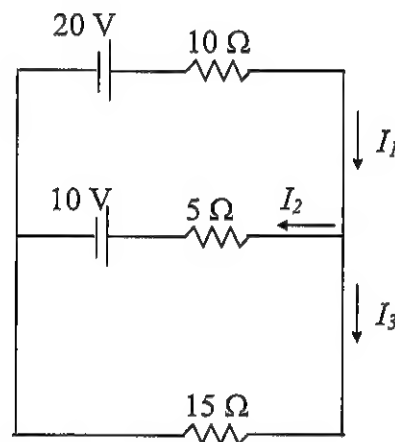

Figure Q2(b)

[5 marks]

(c) Find the equivalent Thevenin's resistance (R_{TH}) and the equivalent Thevenin's Voltage (V_{TH}) across resistor R_1 for the circuit shown in Figure Q2(c) below.
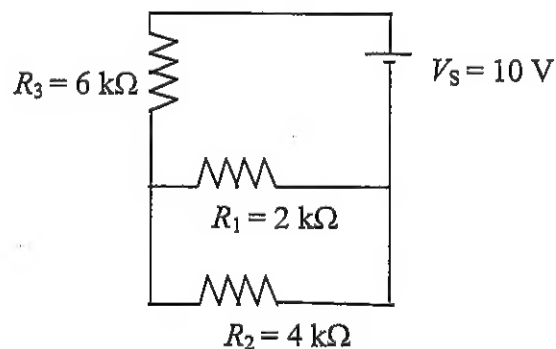

Figure Q2(c)

[3 marks]

Continued...

QUESTION 3 [10 MARKS]

(a) A straight wire has a length of 130 m. This wire carries 50 A current and makes an angle of 70° to the Earth's magnetic field of 0.5×10^{-4} T. What magnitude of force is exerted on this wire?

[2 marks]

(b) An electron is traveling horizontally to the east in a vertically upward magnetic field. The strength of the magnetic field is 0.48 T and the speed of the electron is 2.8×10^4 m/s.

    (i)　Find the magnitude of the force on this electron.　　　　[2 marks]

    (ii)　Determine the direction of the force on this electron.　　　　[1 mark]

(c) (i)　Discuss the effect on the compass due to the magnetic field caused by dc current in the wires.

[2 marks]

    (ii)　Discuss the effect on the compass due to the magnetic field caused by ac current in the wires.

[1 mark]

(d) A 15.0 cm long solenoid, 1.55 cm in diameter is to produce a field of 0.4 T at its center. If the maximum current is 5.0 A, how many turns of wire must the solenoid have?

[2 marks]

Continued...

QUESTION 4 [10 MARKS]

(a)   Consider a basic AC circuit with the maximum voltage V_{max} = 250 V. This source is connected to a 125 Ω resistor. Calculate the rms voltage and rms current in the resistor.

[2 marks]

(b)   A series RLC AC circuit has frequency f = 75.0 Hz, inductance L = 0.750 H, resistance R = 350 Ω, capacitance C = 2.85 μF and maximum voltage V_{max} = 160 V.

    (i)   Determine the impedance of the circuit.   [3 marks]

    (ii)   Find the maximum current in the circuit.   [1 mark]

    (iii)   Calculate the phase angle.   [1 mark]

    (iv)   Find the maximum voltage across the resistor, inductor and capacitor.

[3 marks]

Continued...

QUESTION 5 [10 MARKS]

(a) Discuss the differences between n-type and p-type semiconductors in terms of their impurity, majority carrier and minority carrier.

[4 marks]

(b) Calculate the average value of a full-wave rectified voltage with a peak value of 175 V.

[1 mark]

(c) Figure Q5(c) shows a silicon transistor circuit. Find I_B, I_E, and I_C in Figure Q5(c), given that V_{BB} = 3V, R_E = 2.0 kΩ and V_{CC} = 20 V. Assume that α_{DC} = 0.96 and β_{DC} = 24.

Figure Q5(c)

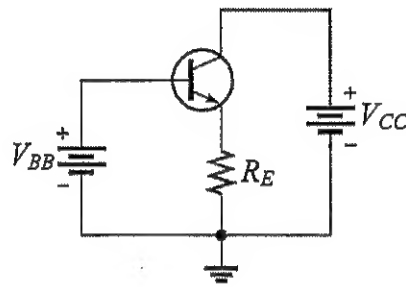[5 marks]

APPENDIX 1

Physical Constants

Quantity	Symbol	Value
Electron mass	m_e	$9.11 \times 10^{-31}\,\text{kg}$
Proton mass,	m_p	$1.67 \times 10^{-27}\,\text{kg}$
Elementary charge	e	$1.602 \times 10^{-19}\,\text{C}$
Gravitational constant	G	$6.67 \times 10^{-11}\,\text{N·m}^2/\text{kg}^2$
Gas constant	R	$8.314\,\text{J/K·mol}$
Hydrogen ground state	E_o	$-13.6\,\text{eV}$
Boltzmann's constant	k_B	$1.38 \times 10^{-23}\,\text{J/K}$
Compton wavelength	λ_c	$2.426 \times 10^{-12}\,\text{m}$
Planck's constant	h	$6.626 \times 10^{-34}\,\text{J·s}$
Speed of light in vacuum	c	$3.0 \times 10^8\,\text{m/s}$
Rydberg constant	R_H	$1.097 \times 10^7\,\text{m}^{-1}$
Acceleration due to gravity,	g	$9.81\,\text{m/s}^2$
Atomic mass unit (1u)	u	$1.66 \times 10^{-27}\,\text{kg}$
Avogadro's number	N_A	$6.023 \times 10^{23}\,\text{mol}^{-1}$
Threshold of intensity of hearing	I_o	$1.0 \times 10^{-12}\,\text{W/m}^2$
Coulomb constant	k	$8.988 \times 10^9\,\text{N m}^2/\text{C}^2$
Permittivity of free space	ε_0/κ_0	$8.85 \times 10^{-12}\,\text{C}^2/\text{N·m}^2$
Permeability of free space	μ_o	$4\pi \times 10^{-7}\,\text{H/m}$

Energy equivalent of atomic mass unit:
One atomic mass unit (1.0 u) is equivalent to 931.5 MeV

Continued...

APPENDIX II

List of formulas

$$A_v = \frac{V_c}{V_b}$$

$$\alpha_{dc} = \frac{\beta_{dc}}{\beta_{dc}+1}$$

$$\beta_{dc} = \frac{\alpha_{dc}}{1-\alpha_{dc}}$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \mu_0 n I$$

$$\xi = V + Ir$$

$$\xi = blv$$

$$\xi = -N\frac{\Delta\Phi}{\Delta t}$$

$$\xi = -L\frac{dI}{dt}$$

$$\xi = -M\frac{dI}{dt}$$

$$F = BIL\sin\theta$$

$$F = qvB\sin\theta$$

$$\frac{F}{\ell} = \frac{\mu_0 I_1 I_2}{2\pi d}$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$I_{tot} = \sqrt{I_R^2 + (I_L - I_C)^2}$$

$$I = neA(v_n + v_p)$$

$$I = nev_d A$$

$$I = I_{max}\sin\omega t$$

$$I_{rms} = \frac{I_{max}}{\sqrt{2}}$$

$$I_x = \left(\frac{R_T}{R_x}\right)I_T$$

$$L = \frac{N\Phi_B}{I}$$

$$L = \frac{\mu_o N^2 A}{l}$$

$$M = \frac{N\Phi_B}{I}$$

$$M = \frac{\mu_o N_1 N_2 A}{l}$$

$$P = IV = I^2 R = \frac{V^2}{R}$$

$$P_t = I_{rms}V_{rms}\cos\phi$$

$$P_r = V_{rms}I_{rms}\sin\phi$$

$$P_a = I_{rms}^2 Z$$

$$R = \frac{\rho L}{A}$$

$$R = R_0[1+\alpha(T-T_0)]$$

$$R_T = R_1 + R_2 + R_3 + \dots$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$$

$$r = \frac{mv}{Bq}$$

$$\tau = NBIA\sin\theta$$

$$U = \frac{1}{2}LI^2$$

$$U = \frac{1}{2}B^2 A\frac{l}{\mu_o}$$

$$V_H = Bvd$$

$$V = V_{max}\sin\omega t$$

$$V_{rms} = \frac{V_{max}}{\sqrt{2}}$$

$$V_x = \left(\frac{R_x}{R_T}\right)V_S$$

$$X_C = \frac{1}{2\pi f C}$$

$$X_L = 2\pi f L$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\oint B.dl = \mu_o I$$

$$d\mathbf{B} = \frac{\mu_0 I}{4\pi}\frac{d\ell \times \hat{\mathbf{r}}}{r^2}$$

$$\Phi_B = BA\cos\theta$$

$$\cos\phi = \frac{R}{Z}$$

$$\tan\phi = \frac{X_L - X_C}{R}$$

End of Paper